Mass Based on its Spatiotemporal Curvature

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Abstract

Any coherent mass formation, regardless of its density, is subject to a relativistic curvature, which, as proven here, accounts for a certain proportion of the Schwarzschild radius. General Relativity reveals a minimum state of this proportion for quantum-sized structures and thereby unveils a fundamental spectrum.

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1. Introduction

My results show that the object-specific amount of gravitationally caused spatiotemporal curvature, which I denote by the symbol $\boldsymbol{L}$, is directly proportional to the mass of all objects that lie in the same region of a curvature spectrum. The maximum value of $\boldsymbol{L}$ must be the Schwarzschild radius $\boldsymbol{r_S}$. This study proves that it is not only this extreme case that exhibits the aforementioned proportionality. $\boldsymbol{L}$ produces a mass-specific spectrum between $\boldsymbol{r_S}$ and a fundamental $\boldsymbol{L_{min}}$ for which size and density of a mass are small and low enough for gravity to tend to zero.

2. Gravitational Relativistic Contraction

Since all mass-based objects cause gravitational time dilation, I investigated how this relativistic curvature of spacetime, represented by a specific radial contraction, might be related to mass.

To obtain the gravitational time dilation on a mass surface, the reciprocal Lorentz factor $\boldsymbol{\alpha}$ depending on the surface escape velocity $\boldsymbol{v_e}$, which is expressed by the mean radius $\boldsymbol{r}$ and surface gravity $\boldsymbol{g}$, can be used to avoid $\boldsymbol{M}$ and $\boldsymbol{G}$:

$$\boldsymbol{\alpha} = \sqrt{1 - \frac{v_e^2}{c^2}} = \sqrt{1 - \frac{2gr}{c^2}} \tag{1}$$

For time dilation states below the surface of a uniformly dense mass, the local escape velocity $\boldsymbol{v_{x+e}}$ has to be used to provide the correct data for the Lorentz factor.

At a specific distance $\boldsymbol{r_x}$ from the center of mass

$$\begin{aligned} {v_{x+e}}^2 &= {v_x}^2 + {v_e}^2 \\ &= 2 \cdot \frac{g + \frac{r_x}{r} \cdot g}{2} \cdot (r - r_x) + 2gr \\ &= 3gr - g \cdot \frac{{r_x}^2}{r} \end{aligned} \tag{2}$$

$$\boldsymbol{\alpha}(r_x) = \sqrt{1 - \frac{g\,(3r^2 - {r_x}^2)}{rc^2}} \tag{3}$$

$\boldsymbol{\alpha}(\boldsymbol{r_x})$ represents the distance-dependent Lorentz factor related to the center of mass. This optimized function can be used to obtain the local extent of radial relativistic contraction. To do this, we must integrate $\boldsymbol{1 - \alpha(r_x)}$ from 0 to $\boldsymbol{r}$:

$$\begin{aligned} L &= \int_0^r \big(1 - \alpha(r_x)\big)\, dr_x \\ &= \int_0^r \left(1 - \sqrt{1 - \frac{g\,(3r^2 - {r_x}^2)}{rc^2}}\right) dr_x \end{aligned} \tag{4}$$

With this formula, the radius of a uniform mass is evaluated over its entire distance according to the Lorentz contraction valid at each position, and all local contraction deltas are summed up.

For a black hole with $\boldsymbol{2gr = c^2}$ we get as expected

$$L_{max} = (1 - 0) \cdot r = r_S \tag{5}$$

To determine the possible spectrum of $\boldsymbol{L}$ we need to look for its minimum. If $\boldsymbol{g}$ and $\boldsymbol{r}$ tend to zero, $\boldsymbol{\alpha}(\boldsymbol{r_x})$ can be simplified

$$\underset{(g,r)\to(0,0)}{\boldsymbol{\alpha}(\boldsymbol{r_x})} = \lim_{(g,r)\to(0,0)} \sqrt{1 - \frac{g\,(3r^2 - r_x^2)}{rc^2}} = 1 - \frac{g\,(3r^2 - r_x^2)}{2rc^2} \quad (6)$$

to ignore the relativistic progression of $\boldsymbol{L}$. Excitingly, the resulting minimum contraction is a fixed fraction of the Schwarzschild radius:

$$L_{min} = \int_0^r \frac{g\,(3r^2 - r_x^2)}{2rc^2}\,dr_x = \frac{4gr^2}{3c^2} = \frac{2}{3} r_S \quad (7)$$

$\boldsymbol{r_S}$ is exactly **1.5** times larger compared to $\boldsymbol{L_{min}}$ as it takes into account the different gravitational potential values between the surface and the core of the object. The spectrum of spatiotemporal curvatures for any possible mass formations in our universe is therefore

$$\frac{2}{3} r_S \leq L \leq r_S \quad (8)$$

The classic formula for the mass of a black hole

$$M_b = \frac{1}{2} \cdot \frac{r_S c^2}{G} \quad (9)$$

becomes the basis of an object-unspecific version:

$$M = k \cdot \frac{Lc^2}{G} \quad (10)$$

$\boldsymbol{k}$ hast to be adjusted to the respective spectral value of $\boldsymbol{L}$:

$$k = \frac{1}{2} \cdot \frac{r_S}{L} = \frac{3}{4} \cdot \frac{L_{min}}{L} \quad (11)$$

For quantum particles or small structures with very low densities, the mass can therefore be expressed as

$$M_q = \frac{3}{4} \cdot \frac{L_{min} c^2}{G} \quad (12)$$

If using the object-specific $\boldsymbol{L}$ instead of $\boldsymbol{L_{min}}$ in this formula, even the calculated masses of most celestial bodies correspond almost exactly to the values from the NASA reference. This is not surprising because the effect of time dilation on planets and many stars is practically negligible and there is hardly any relevant difference between their specific $\boldsymbol{L}$ and $\boldsymbol{L_{min}}$:

Moon: $r = 1737400\,m$ $g = 1.622\,\frac{m}{s^2}$

$L = 0.000072635313444758\,m$ $L_{min} = 0.000072635313443221\,m$

$M_{☾} \approx 0.75 * \mathbf{0.00007263531\ m} * c\wedge 2/G$
$\approx \mathbf{7.34 \cdot 10^{22}}\ kg$

Venus: $r = 6051800\,m$ $g = 8.87\,\frac{m}{s^2}$

$L = 0.00481936794 5878921\,m$ $L_{min} = 0.004819367943935975\,m$

$M_{♀} \approx 0.75 * \mathbf{0.00481936794\ m} * c\wedge 2/G$
$\approx \mathbf{4.87 \cdot 10^{24}}\ kg$

Earth: $r = 6371000\,m$ $g = 9.81\,\frac{m}{s^2}$

$L = 0.005907198279239902\,m$ $L_{min} = 0.005907198276467089\,m$

$M_{\oplus} \approx 0.75 * \mathbf{0.00590719827\ m} * c\wedge 2/G$
$\approx \mathbf{5.97 \cdot 10^{24}}\ kg$

Sun: $r = 695700000\,m$ $g = 274\,\frac{m}{s^2}$

$L = 1967.399343096\,m$ $L_{min} = 1967.396526477\,m$

$M_{\odot} \approx 0.75 * \mathbf{1967.39\ m} * c\wedge 2/G$
$\approx \mathbf{1.99 \cdot 10^{30}}\ kg$

The digits marked in red show the deviation of the object-specific $\boldsymbol{L}$ from the mass-specific $\boldsymbol{L_{min}}$. However, for neutron stars an adjustment of $\boldsymbol{k}$ according to (10) is necessary:

Typical neutron star: $r = 11000\,m$ $g = 2 \cdot 10^{12}\,\frac{m}{s^2}$

$L = 4552.266474936\,m$ $L_{min} = 3590.150847533\,m$

$M_n \approx \underline{\mathbf{0.591}} * \mathbf{4552.27\ m} * c\wedge 2/G$
$\approx \mathbf{3.62 \cdot 10^{30}}\ kg$

3. Conclusions

A given mass may of course occupy different volumes depending on its substantial matrix and the forces acting on it, but regardless of its actual volume, it produces at least a fixed minimum in terms of its relativistic curvature. $\boldsymbol{L}$ can be viewed as a spatiotemporal spectrum of action for arbitrary mass states in our universe. The presence of a fix $\boldsymbol{L_{min}}$ bound to $\boldsymbol{r_S}$ is a discovery that represents a fundamental value. $\boldsymbol{L_{min}}$ describes the mass horizon of spacetime for its transition to classical mass. It could depict the crucial bulge resulting from a primary excitation state that brought mass out of spacetime, and it could probably be the basis for all mass forms. The distribution of substance in spacetime may initially have been so fleeting that it hardly differed from it.

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